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Dated 29. OCTOBER 2001

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P01/7700 0.00 - 9908105.1

10 APR 1999

Your reference
~~RMV/P95293~~ G11161 JMP. KT (n Sire)

9908105.1

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Please type, or write in dark ink using CAPITAL letters. A prescribed fee is payable for a request for grant of a patent. For details, please contact the Patent Office (telephone 071-438 4700).

The Patent Office

Request for grant of a Patent

Form 1/77

Patents Act 1977

Rule 16 of the Patents Rules 1990 is the main rule governing the completion and filing of this form.

1 Title of invention

1 Please give the title of the invention

DATA TRANSMISSION METHOD

2 Do not give trading styles, for example, 'Trading as XYZ company', nationality or former names, for example, 'formerly (known as) ABC Ltd' as these are not required.

2 Applicant's details

☐ **First or only applicant**

2a If you are applying as a corporate body please give:

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Country *(and State of incorporation, if appropriate)*

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Forenames PETER

SECTION 30 (1977 ACT) APPLICATION FILED : 12/4/00.

2c **In all cases,** please give the following details:

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UK postcode GL17 0RF
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Country UNITED KINGDOM

ADP number
(if known) 6953376001

2d, 2e and 2f:
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3
An address for service in the United Kingdom must be supplied.
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3 Address for service details

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Yes [X] No [ ] ➡ ***go to 3b***

⬇ ***Please give details below***

Agent's name
~~URQUHART-DYKES & LORD~~

Agent's address
~~ST NICHOLAS CHAMBERS~~
~~AMEN CORNER~~
~~NEWCASTLE UPON TYNE~~

Postcode ~~NE1 1PE~~

Agent's ADP number ~~0000164401 9~~

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3b:
If you have appointed an agent, all correspondence concerning your application will be sent to the agent's United Kingdom address.

3b If you have not appointed an agent please give a name and address in the United Kingdom to which all correspondence will be sent:

Name

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4 Reference number

4 Agent's or applicant's reference number *(if applicable)* RMV/P95293

5 Claiming an earlier application date

5 Are you claiming that this application be treated as having been filed on the date of filing of an earlier application?

Please mark correct box

Yes ☐ No ☒ ➡ ***go to 6***

⬇ ***please give details below***

☐ number of earlier application or patent number

☐ filing date

(day month year)

☐ and the Section of the Patents Act 1977 under which you are claiming:

Please mark correct box

15(4) (Divisional) ☐ 8(3) ☐ 12(6) ☐ 37(4) ☐

6 Declaration of priority

6
If you are declaring priority from a PCT Application please enter 'PCT' as the country and enter the country code (for example, GB) as part of the application number.

Please give the date in all number format, for example, 31/05/90 for 31 May 1990.

6 If you are declaring priority from previous application(s), please give:

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7

The answer must be 'No' if:
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- *there is an inventor who is not an applicant, or*
- *any applicant is a corporate body.*

7 Inventorship

7 Are you (the applicant or applicants) the sole inventor or the joint inventors?

Please mark the correct box

Yes [X] No [ ] ➡ ***A statement of Inventorship on Patents Form 7/77 will need to be filed (see Rule 15).***

8

Please supply duplicates of claim(s), abstract, description and drawing(s).

8 Checklist

8a Please fill in the number of sheets for each of the following types of document contained in this application.

Continuation sheets for this Patents Form 1/77			
Claim(s)		Description	10 a
Abstract		Drawing(s)	3 + 3

Please mark correct box(es)

8b Which of the following documents also accompanies the application?

Priority documents *(please state how many)*	
Translation(s) of Priority documents *(please state how many)*	
Patents Form 7/77 - Statement of Inventorship and Right to Grant *(please state how many)*	
Patents Form 9/77 - Preliminary Examination/Search	
Patents Form 10/77 - Request for Substantive Examination	

9

You or your appointed agent (see Rule 90 of the Patents Rules 1990) must sign this request.

9 Request

I/We request the grant of a patent on the basis of this application.

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GB9908105.1

By virtue of a direction given under Section 30 of the Patents Act 1977, the application is proceeding in the name of

NSINE LIMITED,

Incorporated in the United Kingdom,

Apex Plaza,
Forbury Road,
Reading,
RG1 1AX,
United Kingdom

[ADP No. 07891534001]

DATA TRANSMISSION METHOD

The present application relates to a method of transmitting data messages in a data network including a plurality of stations interconnected by a bus line. The invention relates particularly, but not exclusively, to a method of transmitting data between computers interconnected by electrical power lines.

A method for operating a data processing arrangement for motor vehicles in which the data processing arrangement includes at least two computers and a bus line connecting the computers for transmitting data messages is disclosed in US Patent No 5001642 and US Patent No 5524213. This method operates according to a protocol known as CAN (Controller Area Network), the details of which are disclosed in ISO (International Standards Organisation) Specification No 11898.

A CAN data message of the known type is shown in Figure 1. The data message includes a start of frame part (1) which indicates to the data network that a message has started, and an arbitration field (2) which determines the priority of the message when two or more nodes of the network are contending for the data bus. In a first version of CAN, the arbitration field (2) contains an 11 bit identifier (3) and a remote transmission request (RTR) bit (4), which is dominant for data frames and recessive for remote frames (the significance of which will be described below). Alternatively, in a second version, the identifier (3) can be a 29 bit identifier containing 2 bits substitute remote request (SRR) and identifier extension (IDE). The SRR bit gives priority to the

version of CAN discussed above if, on a network carrying messages of both versions, both messages have the same 11 bit identifier. The IDE bit (6) differentiates between 29 bit identifiers (which are recessive) and 11 bit identifiers (which are dominant).

The data message also includes a control field (7) which contains for the first version of CAN discussed above the identifier extension bit plus one reserved bit (r0), both set to dominant, and a 4 bit data length code (DLC) part which represents the number of bytes in a data field (8) of the message. In the second version, the control field 7 also includes 2 reserved bits (r1 and r0) which are set to dominant, and a 4 bit data length code, also representing the number of bytes in the data field (8). The data field (8) contains zero to eight bytes of data.

Following the data field (8), a CRC (Cyclic Redundancy Check) field (9) contains a 15-bit checksum calculated on the significant parts of the message and is used for error detection. An acknowledgement slot (10) then follows the CRC field (9). Any CAN controller that has been able to correctly receive the data message sends an acknowledgement bit during the acknowledgement bit time, and the device transmitting the message checks for the presence of the acknowledgement bit. If an acknowledgement bit is detected, the next data frame is sent, but if no acknowledgement bit is detected, the device re-transmits the data frame. Prior to re-transmission, the node transmits an error frame, then waits for 8 times the frame bit rate period before re-transmitting.

Figure 2 shows a remote frame for use with the CAN data frame shown in Figure 1, and parts common to the frame of Figure 1 are denoted by like reference numerals but increased by 100. The remote frame is similar to the data frame in that it incorporates a start of frame 101, an arbitration field 102 having an identifier 103, a control field 107, a CRC field 109

and an acknowledgement slot 110. However, the remote frame does not contain a data field, and the RTR bit in the arbitration field is recessive for the purpose of explicitly marking the frame as a remote frame.

The purpose of the remote frame is to solicit the transmission of the corresponding data frame. For example, if a node A transmits a remote frame with its arbitration field 102 set to 234, then node B, if properly initialised, may respond with a data frame having its arbitration field (2) also set to 234.

Figure 3 shows an error frame for use in the network on which the frames of Figures 1 and 2 are transmitted. The error frame is transmitted when a node detects a fault, and causes all other nodes to detect a fault so that they also send error frames. The message transmitter then automatically tries to re-transmit the message, and a scheme of error counters ensures that a node is unable to destroy the traffic on the data bus by repeatedly transmitting error frames.

The error frame includes an error flag (20) consisting of 6 bits of the same value (which thus violates the bit-stuffing rule, as will be familiar to persons skilled in the art), and an error delimiter (21) comprising 8 recessive bits. The error delimiter provides a space in which other nodes on the bus can send their error flags when they detect the first error flag. Finally, an overload frame (not shown) may be used, and is similar in format to the error frame discussed above. The overload frame is transmitted by a node that becomes too busy.

The prior art arrangement discussed above suffers from the drawback that the rate at which data can be reliably transmitted across the network is limited by the distances the data must travel between nodes of the network. When messages consisting of small amounts of data are transmitted across small distances (for example data representing physical measurements in a motor vehicle transmitted around a data bus

located in the vehicle) this does not cause any significant difficulty. However, if larger amounts of data need to be transmitted over larger distances (for example transmission of large amounts of data between computers separated by significant distances), then the rate at which data can be transmitted prevents the prior art CAN arrangement discussed above from being practicable. In particular, the prior art CAN arrangement discussed above can only transmit a maximum of 8 bytes per data frame, and the number of data bits per data frame divided by the maximum distance in metres times the data bit rate (the payload) is limited to 1.6.

Preferred embodiments of the present invention seek to overcome the above disadvantages of the prior art.

According to the present invention, there is provided a method of transmission of data messages between a plurality of stations interconnected by a bus line, wherein each said message includes a frame portion representing content and priority information of the data message and a data portion representing data to be transmitted, the method comprising the steps of causing at least one said station to transmit a data message on to the bus line such that said frame portion thereof is transmitted at a first data transmission rate, and the data portion thereof is transmitted at a second data transmission rate not less than said first data transmission rate.

The present invention is based on the very surprising discovery that by transmitting the data portion of a data message at a second data transmission rate which may be higher than the first data transmission rate at which the frame portion of the message is transmitted, the rate of transmission of data can be significantly improved compared with the prior art, without significant lowering of the distances over which data can be reliably transmitted (which would be the case if the entire data message were to be transmitted at the second transmission rate). For example, whereas the payload for conventional CAN

arrangements is limited to 1.6, the payload for arrangements embodying the present invention can be as high as 102.4.

In a preferred embodiment, said frame portion contains information representing a station to which the message is directed.

This provides the advantage of enabling the network to be arranged such that only an addressed node or nodes responds to a particular message.

The frame portion may contain information representing the size of the corresponding data portion.

The second data transmission rate may be an integral multiple of said first data transmission rate.

The method may further comprise the step of causing at least one further station to transmit onto the bus line an acknowledgement signal indicating receipt of a said data message.

The method may further comprise the step of causing at least one said station to transmit a further said data message in response to transmission of a said acknowledgement signal.

This provides the advantage that further messages can be transmitted onto the network immediately after the previous message is correctly received.

The apparatus preferably further comprises the step of re-transmitting a said message if no acknowledgement signal is received.

The method may further comprise the step of generating an error message prior to re-transmission of said message.

In a preferred embodiment, the method further comprises the step of adjusting said first and/or second data transmission rate in response to the frequency of generation of said error messages.

This provides the advantage of enabling the network to automatically adjust itself to the first and second data transmission rates which provide the most advantageous balance between speed and reliability of transmission.

A preferred embodiment of the invention will now be described, by way of example only and not in any limitative sense, with reference to the accompanying drawings, in which:-

Figure 1 is a prior art CAN data message;

Figure 2 is a remote frame for use in conjunction with the data message of Figure 1;

Figure 3 is an error frame for use in conjunction with the data message of Figure 1 and remote frame of Figure 2;

Figure 4 is a data message for use in a method embodying the present invention; and

Figures 5A and 5B are a flow diagram showing the switching between the first and second data transmission rates of the method embodying the present invention.

Referring to Figure 4, a data frame for use in a method embodying the present invention has a start of frame 201, arbitration field 202 containing an identifier 203, RTR bit 204 substitute remote request bit 205 and identifier extension bit 206. These features operate in a similar manner to the corresponding features of the prior art data frame of Figure 1, with the exception that the arbitration field 203 may contain information regarding the transmit and receive node

identification, the size of data field 208 and the rate of transmission of the data contained in the data field 208.

The message also has a control field 207 which includes a data length code (DLC), the fourth bit of which may contain information regarding the size of the data field 208. The data field may be increased in size from 8 bytes in the prior art data field to 2048 bytes. If the rate of transmission F2 of the data in the data field 208 is an integral multiple of the rate of transmission of the data in the arbitration field 203 and control field 207, the multiplier may be set by the unused r0 and r1 bits of the control field 207. F1 bit rates are typically from 10Kbit to 1Mbit, and F2 bit rates are typically from 10Kbit to 8Mbit, although these bit rates may be changed arbitrarily depending on the particular construction of the network.

When the network is initially set up, the user may configure the F1 and F2 bit rates to particular values, and then by monitoring the rate of production of error frames during test transmissions determine the most reliable F1 and F2 bit rates to set for the particular network. A table containing a guideline for the initial settings may be provided, the table based upon the lengths of cable in the network. A test program to automate the task of setting F1 and F2 may also be provided, and these settings may then be stored in a non-volatile memory and thus be available for reuse each time the device is switched on.

A device containing a node operating using the method of the present invention may use a low level device driver to automate the task of setting F1 and F2. By repeatedly running the program of the low level device driver during a network session, the node can update the F1 and F2 bit rates held in the non-volatile memory to higher or lower values, depending upon the signalling conditions on the physical network at that

time. This ensures that transmission bit rates are optimised adaptively for reliability and speed.

The embodiment described above includes in the arbitration field 202 a number of coded bits to identify the transmitting node and the identity of the intended receiving node or nodes. When all nodes receive the data frame, they compare the bits in the arbitration field 202 with the bits and their message address filter (as will be familiar to persons skilled in the art) to determine whether the data frame is addressed to them or not. If not, they switch to a passive mode, which ensures that only the node that the message is intended for will acknowledge the message if it is received without error. The transmitter may then determine that the message was received by the correct node, without error, and not simply by just any node on the network.

The 4 bit data length code within the control field 207 has seven unused values in the prior art CAN arrangement discussed with reference to Figures 1 to 3 (9 to F hexadecimal). In the present invention, these unused values can be used to indicate a number of bytes in the data field as shown in Table 1 below:

DLC Value in Hex	**Data Field Length in Bytes**
O to 8	O TO 8
9	32
A	64
B	128
C	256
D	512
E	1024
F	2048

An alternative method of indicating the number of bytes in the data field 208 may be to use any of the 29 bits available in the identifier 203 in a predetermined pattern. This

alternative method may be used to increase the number of different data field bytes available to the user.

As pointed out above, the 2 reserved bits in the control field 207 may be used to indicate that the data transmission rate F2 of the data field 208 is an integral multiple of the data transmission rate F1 of the arbitration field 202 and control field 207. This may be carried out according to Table 2 below:

Control Field r1	**r0**	**Multiplier**	**F2 Bit Rate**
0	0	1	F1
0	1	2	2 x F1
1	0	4	4 x F1
1	1	8	8 x F1

An alternative method of indicating the bit rate F2 may be to use any of the 29 bits available in the identifier 203 in a predetermined pattern.

Referring to Figures 5A and 5B, which show a flow chart relating to the method of switching from data transmission rate F1 to F2 and vice versa, frame headers and footers are transmitted at the F1 bit rate, as shown in Figure 4. Before a frame is transmitted, the transmit clock of the relevant transmitter checks a register in a non-volatile memory containing the current F1 bit rate value, and the transmit clock is set to this value for all frame bits. In particular, the transmit sequence begins at Step 501, and if the start of frame portion 201 has begun at Step 502, a counter A is started at 503, otherwise the transmitter returns to Step 502.

After the counter A has started, it is determined at Step 504 whether the counter A has reached the last bit of the control field 208. When the counter detects that the last bit of the control field 208 has been sent, the transmit clock then checks

a register in non-volatile memory containing the current F2 bit rate value and the transmit clock is then changed to F2 at Step 505. A counter B is started at Step 506, and when the counter detects at Step 507 that the last CRC bit has been sent, the transmit clock is reset to F1 at Step 508 for the remainder of the frame.

When an acknowledgement bit has been received at Step 509, the end frame portion is sent at Step 510, and a determination is made at Step 511 whether another frame is to be sent. If another frame is to be sent, the process returns to Step 501. If, on the other hand, no acknowledgement bit is received at Step 509, an error frame is sent at Step 512 and after waiting six times the F1 bit period at Step 513, the process returns to Step 501. If no other frame is to be sent at Step 511, the apparatus waits for the next transmit sequence to start at Step 514, and when the next transmit sequence starts at Step 515, the apparatus returns to Step 501.

It will be appreciated by persons skilled in the art that the above embodiment has been described by way of example only and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope of the invention as defined by the appended claims.

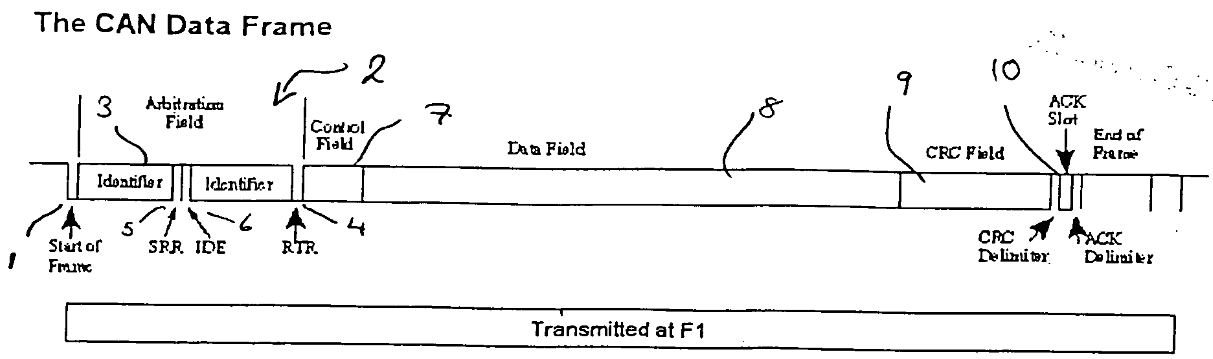

FIG 1 PRIOR ART

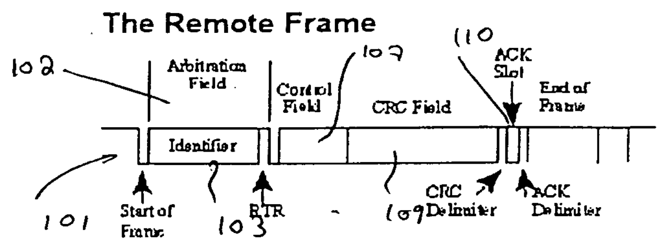

FIG 2 PRIOR ART

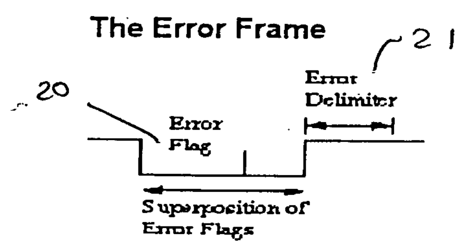

FIG 3 PRIOR ART

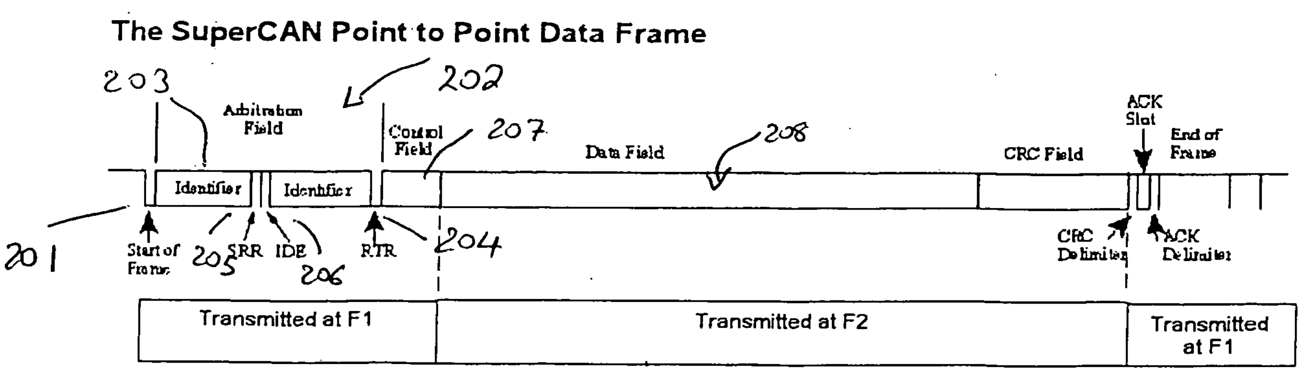

FIG. 4

2/3

METHOD OF SWITCHING FROM F1 TO F2 etc

FLOW CHART

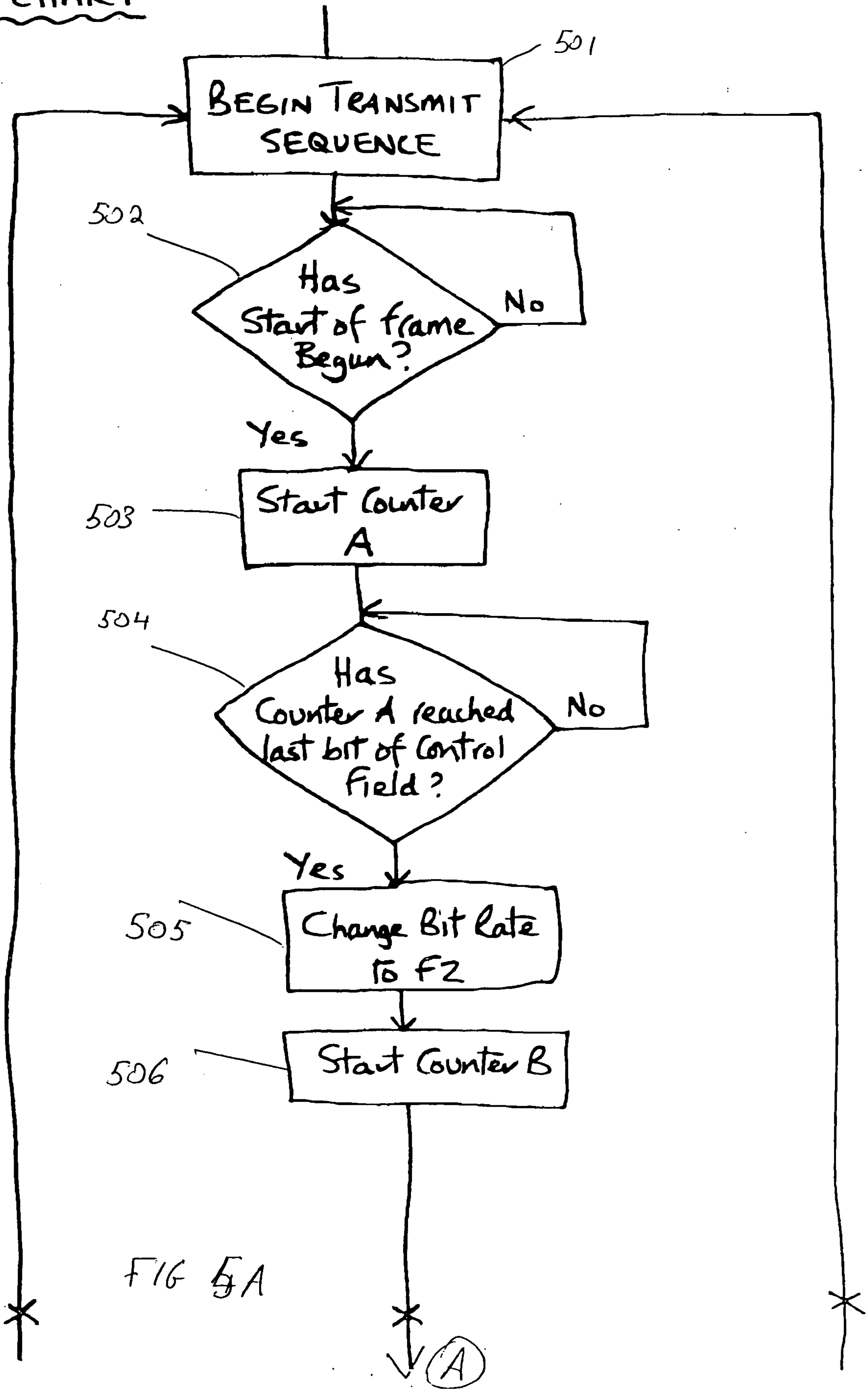

FIG 5A

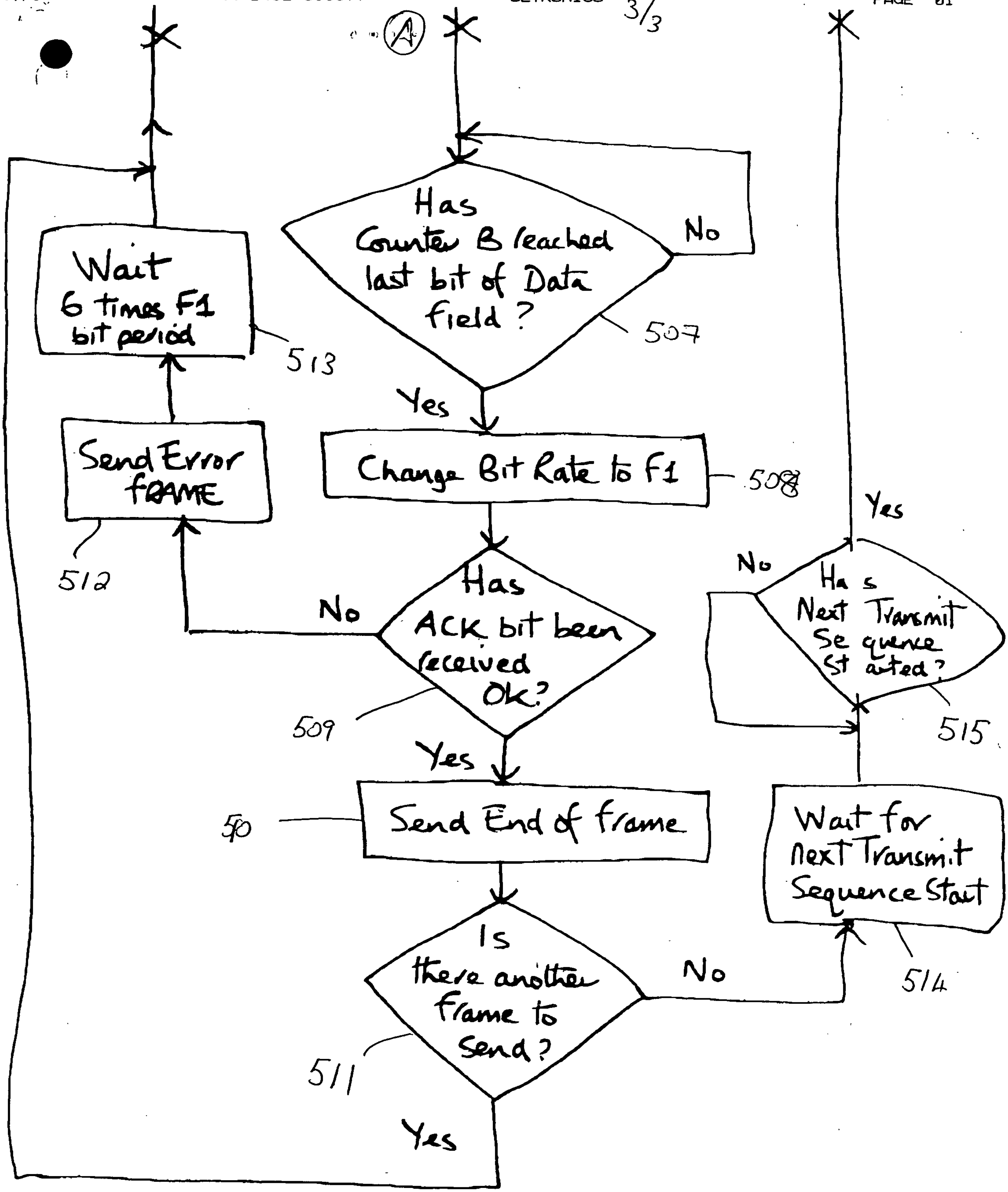
A
Has Counter B reached last bit of Data field ?
No
507
Yes
Change Bit Rate to F1
508
Wait 6 times F1 bit period
513
Send Error FRAME
512
Has ACK bit been received OK?
No
509
Yes
Send End of frame
510
Is there another frame to send?
511
Yes
No
Wait for Next Transmit Sequence Start
514
Has Next Transmit Sequence Started?
No
Yes
515

FIG 5B